THE STUDY OF CYCLONE SPRAY TOWERS

BY
HERBERT ERNEST SILCOX
B.S., University of New Hampshire, 1936
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THESIS
SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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ACKNOWLEDGEMENT

The author wishes to express his appreciation to Professor H. F. Johnstone, under whose direction this investigation was made. He is also indebted to Oliver R. Kirby for his aid in the experimental work. This work represents a part of the cooperative research project entitled "A Study of the Stack Gases," sponsored by the Utilities Research Commission of Chicago, Illinois.

THE STUDY OF CYCLONE SPRAY TOWERS

Introduction

The cyclone spray tower consists of a cylindrical chamber with a tangential gas inlet of suitable cross section near the bottom and a central gas exit at the top. A suitable spray of finely atomized particles of the scrubbing fluid is formed near the axis of the cylinder in the region directly above the inlet. Rotation of the gas in the chamber, due to the tangential entrance of the gas at a controlled velocity, causes the spray particles to travel outward at a high velocity through the gas to the walls of the chamber.

The cyclone spray tower has found application in the removal of fog and dust particles from large quantities of gases. Some work has been carried out relative to the absorption of soluble gases from a gas stream, and it seems probable that the tower would offer advantages in any process involving heat or mass transfer between gas and liquid phases.

At the time the cyclone tower was patented, there was little information available which might serve as a basis of design. Since that time a few brief investigations have given some insight into the theory of the tower performance. The purpose of this research was to extend this information, particularly with respect to gas absorption.

Experimental

The tower consisted of a chamber 14 feet high, 28.5 inches i.d. at the bottom and 20.5 inches i.d. at the top. The tower was tapered and constructed of cellulose acetate sheeting, 0.02 inches thick, which was supported by an outside metal framework. The gas was blown into the tower by means of a fan (1,000-10,000 cubic feet per minute) through a 14-inch i.d. pipe. The exit gases were removed through a 14-inch i.d. central outlet in the top.

Sodium carbonate solution was introduced into the tower through a spray manifold on which were placed 98 spray nozzles (Spraco, type T, 0.046 inch orifice diameter). The nozzles were placed spirally around the manifold, spraying solution in the direction of the gas flow and at an angle of 30° above horizontal. The sodium carbonate solution drained down the walls and back to the supply tank through an outlet in the bottom of the tower. Sulfur

dioxide was introduced into the gas stream just following the fan. For the purpose of studying the amount of absorption taking place on the wall, a single 1-inch i.d. spray coil was placed on the tower wall 8 feet up from the bottom of the tower.

Studies were made of the variation of absorption efficiency with gas rate, liquid rate, and inlet design. Parallel to the absorption efficiency studies, data were taken pertaining to flow pattern of the gases in the tower.

Conclusions

1. The absorption efficiency is independent of the liquid concentration.

2. For films flowing down the tower wall the gas film resistance definitely controls the absorption.

3. The absorption by the liquid flowing down the tower wall is dependent on the gas velocity at the wall. For the particular tower studied this relationship may be represented by the equation

$$n(w) = \frac{0.145\ Aw}{Vw^{0.418}}$$

4. There is no interference between sprays from the nozzles as they were distributed on the manifold and the absorption efficiency is proportional to the first power of the liquid rate.

5. The absorption efficiency is inversely proportional to the 0.74-0.76 power of the gas rate.

6. The horizontal component of velocity at the wall and the maximum horizontal velocity component are linear functions of the gas rate and may be represented by the equations,

$$Vmax = t_1 G$$
$$Vw = t_2 G$$

The values t_1 and t_2 are dependent on the specific inlet arrangements.

7. The absorption efficiency for the tower and system studied may be represented by the equation,

$$n(T) = n(s) + n(w) = \frac{422\ W}{G}\,(Vave)^{0.261} + \frac{0.145\ Aw}{Vw^{0.418}}$$

It must be remembered that this equation does not take into account the effect of diameter. Based upon theoretical considerations the efficiency of absorption varies as the first power of the diameter.

Nomenclature

Aw = Area of wetted wall (ft.^{2}).

G = Gas Rate (ft.^{3}/min.).

Vw = Horizontal component of velocity at wall (ft./min.).

Vmax = Maximum horizontal component of velocity (ft./min.).

Vave = Average horizontal component of velocity (ft./min.).

$$= \frac{\text{Vmax} + \text{Vw}}{2}$$

W = Liquid Rate (ft.^{3}/min.).

n(T) = Total number of transfer units.

n(s) = Number of transfer units due to spray.

n(w) = Number of transfer units due to wall.

t_1 and t_2 = Constants relating velocity and flow rate for different inlet arrangements.

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Vita

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